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Science Response 2015/020

PRE-COSEWIC REVIEW OF THE SAKINAW SOCKEYE SALMON *(ONCORHYNCHUS NERKA)* POPULATION 2014

Context

The Sakinaw Lake population of Sockeye Salmon, *Oncorhynchus nerka*, was designated as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in an emergency listing in 2002 (COSEWIC 2003). Their status was reviewed and confirmed in 2003, with an emergency reassessment in 2006. Though designated endangered by COSEWIC, this population was not listed under the Species at Risk Act (SARA). COSEWIC is currently (2015) re-assessing the status of Sakinaw Sockeye. When an aquatic species is assessed, and Fisheries and Oceans Canada (DFO) is a primary data holder, it is common practice to provide corporately held data in the form of a pre-COSEWIC review. The purpose of this Regional Science Response Process (RSRP) is to review available DFO information relevant to the COSEWIC criterion to assess the status of Sakinaw Sockeye. Results of this RSRP will be made available to COSEWIC, the author(s) of the species status report, and the co-chairs of the applicable COSEWIC Species Specialist Subcommittee.

This Science Response results from the Science Response Process of January 2015 on the Pre-COSEWIC Assessment for Sockeye Salmon Sakinaw Population.

Analysis and Response

Review of Designatable Units

Designatable Units are defined by COSEWIC as "A population or group of populations... [that] has attributes that make it "discrete" and evolutionarily "significant" relative to other populations" (COSEWIC 2013). The sockeye population reproducing in Sakinaw Lake (henceforth Sakinaw Sockeye) satisfies both of these criteria for a Designatable Unit. Sockeye Salmon populations are reproductively isolated, reproducing in freshwater lakes that have led to genetic distinction and local adaptation to conditions specific to the respective lakes. Sakinaw Sockeye have been shown to be genetically distinct through genetic variation in allozymes (Wood et al. 1994), microsatellite DNA (Nelson et al. 2003) and mitochondrial DNA (Murray and Wood 2002). Distinctness is also evident in the large smolt size, small adult size, and low fecundity of Sakinaw Sockeye.

Extent of Occurrence and Area of Occupancy

Extent of Occurrence refers to "the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon" (IUCN 2014). In North America, Sockeye Salmon (not specific to Sakinaw population) occur from the Columbia River in the south to the Nome River, Alaska, in the north. Juveniles tend to remain primarily inshore through September-October, and migrate offshore in late autumn or winter (Burgner, 1991). Sakinaw Sockeye reproduce exclusively in Sakinaw Lake (surface area 6.9 km^2) (DFO 2008).

Area of Occupancy is "the area within [a species] 'extent of occurrence' which is occupied by a taxon...", which reflects the fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitat" (IUCN2014). Area of occupancy for the freshwater phase also falls within Sakinaw Lake, with spawning occurring at specific beaches with a total area of ~2.1 km^2 (Grant McBain, DFO, Oceans, Habitat and Enhancement, Madiera Park, BC, pers. comm.). Therefore, all reproduction occurs in Canadian waters. The DFO dam, installed in 1952, imposed a limitation on fluctuation of the depth of the lake. Without the dam the lake would fluctuate +/- 90 cm. The Sakinaw Lake Sockeye population is reproductively isolated from other Sockeye, with no evidence of fragmentation within this population. Juvenile migration to the North Pacific occurs through Johnstone Strait. Returning adult migration is primarily through Johnstone Strait; however, there have been a small number of Sakinaw Sockeye caught in DFO test fishery sets in the Juan de Fuca Strait and Gulf Island areas, suggesting that some small portion of the population return along the southern Vancouver Island approach through the Strait of Georgia.

Life History Characteristics

Sockeye Salmon are one of the seven Pacific salmon species (Order Salmoniformes, Family Salmonidae) in Canada. They are primarily anadromous, though there are some fully freshwater populations ("Kokanee"). Sockeye exist as reproductively isolated populations, each returning to spawn in their natal freshwater habitats (streams, lakes or tributaries). Juveniles tend to make greater use of freshwater nursery habitat than other Pacific salmon, remaining in freshwater for up to three years before migrating to the Pacific Ocean.

The Sakinaw Sockeye population reproduces in Sakinaw Lake on the Sechelt Peninsula in the Strait of Georgia in southwestern BC (Figure 1). This population is generally smaller at maturity than other sockeye, and has a larger smolt size due to a high level of productivity in Sakinaw Lake. Sakinaw Sockeye usually mature at four years, with small numbers maturing at three or five years. Length at maturity (adult fork length) data are available from 2001 wild-caught adults for the captive brood program, and from 2004, 2005, and 2011 fish tunnel video measurements. Average length for 178 animals between 2001 and 2013 is 55 cm (range 28-84 cm). Data for lengths collected in the most recent years are given in Table 2. Juveniles usually spend one year rearing in the lake (approximately 5% spend two years), followed by two (sometimes three) years maturing at sea before returning to Sakinaw Lake as adults to spawn. Ages of smolts have been collected annually through the DFO Assessment Project (Table 4), divided into clipped (hatchery fish) and unclipped (natural spawner origin fish) (note that hatchery fish weren't clipped for brood years 2008, 2009 and 2010). In 2010, the unclipped sockeye smolts originated from both hatchery and natural spawners. Kokanee are also known to inhabit Sakinaw Lake.

Sockeye fecundity is in the higher end of the range for Pacific salmon. For females collected for brood stock in 1986, 1987, 2000 and 2001, average fecundity was 2796 (n=69; Murray and Wood 2002). Recent fecundity estimates including brood years (BY) 2000-2002, 2004-2005 and 2010 average 1512 (range 0-3096, n=72). These values fall in the lower range for fecundity for most sockeye populations of 2000 to 5200 eggs (Bergner 1991).

Sakinaw Sockeye spawn from mid-November to mid-December. After egg deposition, females remain over the redds until near death, deterring other females and sometimes males from disturbing the redds. Eggs incubate in gravel, and fry (25-32 mm) emerge between late February and early March, initially feeding in the littoral zone, then moving to the limnetic zone between January and June (Burgner 1991). A recent DFO study examined egg-fry survival (from eyed-egg stage) in gravel at 21 sites on four spawning beaches in Sakinaw Lake in 2013

(Haskin's beach and three subareas of Sharon's beach: Snag, Fraser's and Morgan's). Average egg to fry survival was 78%, ranging from 20% to 100%. Survival of fry to smolts is known from hatchery fry (BY 2001, 2002, 2004-2013), and averages 14.6% (range 1.4% to 32.2%).

Smolts migrate to the Pacific Ocean through Johnstone Strait in spring and remain at sea for two to three years before returning to Sakinaw Lake as adults (most return between late June to early August, but may return as early as mid-May and as late as early September). Average smolt size from 1994 to 1997 was reported by the Sechelt Indian Band to be 122.4 mm, 139.2 mm,
133.0 mm and 129.0 mm in 1994, 1995, 1996, and 1997 respectively (Bates and August 1997 *in* Murray and Wood 2002). Smolt length data from 2014 are presented in Table 3. Smolt age data from 2003-2014 are presented in Table 4.

Average smolt to adult survival rate for sockeye (not specific to the Sakinaw population) reported as roughly 4.5% (Forester 1968). Murray and Wood (2002) reported smolt-adult marine survival for Sakinaw based on BY 1992 and 1995 smolt counts and 1996 and 1999 escapements (not separated into fishery and natural mortality) estimated at 0.83%. Data from recent years shows a smolt to adult survival (marine survival) average of 0.28% (BY 2001, 2004-2010) for hatchery and 0.40% (BY 2001, 2002, 2004-2006; Table 5) for natural origin sockeye. These rates are below what is required for natural sustainable levels

Adult spawners hold in the lake for up to four months before spawning (Murray and Wood 2002). In–lake mortality during holding is unknown, but is assumed to be very low. Dive counts have been conducted, but are often unreliable estimates of fish present and associated in-lake survival, because some fish may be missed on dive surveys and not all beaches are surveyed (Table 6). However, in years with low returns, when thorough dive counts were conducted, (2004 and 2005), the number of fish counted at the fishway and on later dive surveys suggest that mortality is 10% or less.

Habitat Characteristics

Sakinaw Lake is in the Sechelt region with a climate characterized by warm, dry summers and mild, wet winters. The lake consists of two basins. The upper basin has a maximum depth of 40 m, and the lower basin has a maximum depth of 140 m and mean depth of 43 m. Sakinaw Lake is classified as meromictic, meaning that it remains stratified with a fresher surface layer and saline deeper layer that do not mix. Below 30 m depth, water is warmer and is partially saline (up to approximately 11%) and anoxic.

In 1952, DFO installed a dam at the outlet of Sakinaw Lake. The dam is actively managed by DFO to maximize water storage levels in the summer period and to facilitate salmon migration June-October.

Specific beaches in the lake are used by spawning adult sockeye, as identified in 1979, 1999, 2000 and 2001 DFO dive surveys reported in Murray and Wood (2002) and subsequent surveys (Figure 2). Recent surveys have shown that only two of the original five beaches are still actively used. At spawning, Sakinaw Sockeye require beaches with gravel small enough to be moved when digging and with sufficient flow of oxygenated waters. Too much fine sediment in spawning substrate can lead to poor water exchange and low oxygen and high metabolic wastes. Upwelling ground water is essential for successful beach spawning in Sakinaw Lake. Spawning occurs from 25 cm from the lake water surface down to 25 m, with the majority of redds occurring between 3-10 m (Burgner 1991).

There are five known spawning beaches, three in the upper basin (Sharon's, Haskin's and Ruby) and two in the lower basin (Prospector's and Kokomo) of the lake and near stream inlets or groundwater sources. The three upper beaches have been reported to be used for spawning, though in 2001 surveys, Ruby wasn't being used. The remaining beaches appeared to be of poor quality for spawning (surveys as reported in Murray and Wood 2002). 2003-2004 dive surveys assessed nine different sites around the lake. Suitable spawning habitat and conditions were identified, yet some sites appeared not to be used. The upland area from Sharon's beach has been owned by the same family since 1952, and has shown no impacts by residential development or logging. Spawning habitat at this site, however, has been impacted by falling trees and heavy woody debris. Haskin's beach was impacted when "Boat ramp" creek was diverted from its original channel to install the boat ramp, but sockeye still try to spawn in the original spawning bed associated with the channel. DFO has undertaken recent restoration efforts to enhance spawning habitat at known beaches (Sharon's and Haskin's), including clearing of fallen trees from original flooding, woody debris, large rocks and accumulated sediment and loosening of compacted gravel from marked redds.

Population trends

Counts of mature sockeye for population estimates are usually taken as the number of spawners that escape fisheries and return to the lake to spawn (Table1). Data were compiled from DFOBC-16s[1] from 1947-1994. Reliable estimates do not exist for 1995, 1997 and 1998. A partial count in 1996, and complete count in 2002 were made through the fishway in the dam, and 1999-2001 estimates were made by dive survey counts at spawning beaches. Since 2003, counts were made from a digital video system, in the fishway. Estimates at spawning beaches are, presumably, biased by in-lake mortality. This is an unavoidable bias between return estimates at the fishway and estimates at the spawning grounds with an approximate magnitude of up to 10%. Fishway counts provide the highest quality data to inform assessments.

Numbers of mature Sakinaw Sockeye from 1947-1987 showed no apparent trend, varying from 750-16,000 (Table 1). After 1987, escapements declined drastically until 2006 when 0 or 1 adult returned to the lake each year from 2006-2009. Given that the generation time for sockeye is four years, the population went extinct in the wild.

During the collapse of the population, a captive brood program was initiated to supplement the declining returns. Wild adults (n=84) were used to establish this captive population from escapement in 2002-2005 (Withler et al. 2014). The entire Sakinaw population is now descended from the captive population. Hatchery fry are released into the upper basin of Sakinaw Lake annually, with subsequent smolt enumeration and adult returns assessment. Between 29 and 554 of hatchery-released fish returned to spawn from 2010 to 2014. Numbers of fry released from hatcheries from 2001-2014, as well as smolt counts out-migrating from the lake from 2003-2014, are provided in Table 5. Hatchery-released fish are marked with an adipose fin clip prior to release to allow identification of smolts and returned adults as being of hatchery or natural spawner origin. Hatchery fry were not clipped 2009-2011 as all returns in 2012-2103 are assumed to have originated from hatchery. Sixteen reintroduced adults spawned naturally in the lake in 2010, but resulting smolts were not discernable from hatchery fish (Withler et al. 2014). Clipping resumed in 2012.

[1] BC16s are the individual records where salmon spawning counts are recorded for each stream. Data from these reports are housed in DFO regionally managed NuSEDS database.

Hatchery fry from the captive brood program continue to be produced to supplement natural recruitment while escapements remain low. Hatchery fry released between 2001 and 2014 varied from 0 to 1,373,822 fry (Table 5). Smolts counted out-migrating from the lake between 2003 and 2014 range from 13 smolts in 2005 to 252,535 smolts in 2011. The ongoing smolt enumeration and adult return assessment, combined with adipose clipping to discern between hatchery and natural spawned fish, provide valuable data to assess freshwater and marine survival of both naturally-spawned and hatchery-produced fish. Based on these data, the estimates of survival indicate that the current bottleneck for Sakinaw Sockeye recovery is in the marine environment, though specific causes are unknown (Withler et al. 2014). The collection of these valuable data results from a strong collaboration between the Sechelt Band, Salmonid Enhancement Program, and DFO Science.

Sakinaw Sockeye co-occur with migrating Fraser River Sockeye in Johnstone Strait and these stocks are therefore co-managed. DFO has altered fisheries management practices to reduce impacts of salmon fisheries for Sakinaw Sockeye in the marine phase. The following excerpt from a draft DFO report updating the conservation strategy for Sakinaw Sockeye summarizes fisheries management efforts to minimize exploitation of Sakinaw in the mixed fishery (Andrea Goruk, DFO, Fisheries Management, Nanaimo, BC, pers. comm.):

"Sakinaw Lake sockeye are considered most vulnerable to harvest directed at Fraser River stocks through to late July. To protect Sakinaw Lake Sockeye most potential interception fisheries (commercial and recreational) are delayed until the last week of July to ensure a significant proportion of the return has passed through the major fisheries in Johnstone Strait. There are sockeye non-retention restrictions in Area 16 until early to mid-August. Commercial fisheries in the upper Strait of Georgia are closed until early to mid-August. The waters near the mouth of Sakinaw Creek are closed to fishing all season. The Sechelt First Nation coordinates fisheries to avoid periods and areas of concern for Sakinaw Sockeye. There is a high level of compliance with these actions".

Residence

SARA s. 2(1) defines Residence as "a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating." Sakinaw Sockeye spawn exclusively in Sakinaw Lake in BC, Canada. Females build redds for egg deposition directly in the gravel substrate on beaches of this lake only. As such these areas could be considered as residence.

Threats to Abundance

The primary threat to the Sakinaw sockeye population is survival in the marine environment. Proportions of mortality related to natural limiting factors, fishing mortality and lake entry challenges for returning adults are unknown. Factors previously identified as potentially influential in the population decline include the non-operation of the fishway, exploitation rates and poor ocean conditions (Withler et al. 2014).

Exploitation through mixed stock fisheries at sea is believed to have contributed to the decline of Sakinaw Sockeye in the past, with high fishing effort and harvest rate in the Strait of Georgia and Johnstone Strait through which Sakinaw Sockeye migrate. Data for exploitation rates depend on a suite of variables, including catch, scale racial analysis and escapement. Using data collected between 1970-2001, Murray and Wood (2002) estimated harvest rates at 37-65% for Johnstone Strait, and 4-29% from Area 16 in the Strait of Georgia, and exploitation rates of

Sakinaw sockeye ranging from 1-67% between 1970-1999. Peer reviewed exploitation rates on Sakinaw Sockeye for recent years are not available.

Migration into Sakinaw Lake via the DFO storage dam and fishway at the lake outlet was impacted throughout the 1990's due to lack of DFO staff required to operate the storage dam and fishway. The fishway trap at the dam (deployed in 1987-88, not used for several years and removed 1996-97) and the fishway itself can facilitate predation by otters and humans. In 1995, DFO installed two rock weirs downstream of the dam to increase the pool depth below the fishway by two metres and reduce the jumps into the fishway from 8 – 30 cm jumps to less than 3 – 30cm. Ongoing monitoring (manned presence) is necessary during migration to minimize predation as a source of mortality. Staffing is also needed to adjust fishway flows as the lake levels drop, and clear any obstacles.

Natural predation, both in the lake and at sea by birds, fish and mammalian predators, can also impact population numbers (Murray and Wood 2002). Fish predators of juvenile sockeye include cutthroat trout, juvenile Coho and Chinook, Prickly Sculpin and lamprey. Birds that prey on juvenile Sockeye include terns, gulls, mergansers, loons, cormorants, grebes, kingfishers, osprey and Bald Eagles. Among potential mammalian predators are river otters, seals, mink and bears.

There is no evidence that all the causes for the decline has ceased. However, it is believed that the declines are reversible, with continued operation of the dam and fishway, habitat restoration efforts, monitoring and reduction of juvenile predation, management of water flows, and fishery management practices that limit fishing mortality. However, marine survival is currently insufficient to sustain the population without hatchery supplementation.

Conclusions

Sakinaw sockeye is being re-assessed by COSEWIC. This Science Response is intended to inform that process. Sakinaw sockeye were extirpated from the wild 2006-2009, and were successfully reintroduced from a captive breeding program (Withler et al. 2014). Although nearly 500 adults returned in 2014, and more than 500 returned in 2011, the population is still under threat. Current survival rates from smolt to adult are not sufficient to sustain the population (Withler et al. 2014), and continued hatchery supplementation is likely required to prevent another extirpation event until survival in the marine environment improves. Spawning habitat has in the past been affected by operating the lake storage at fixed levels, the original flooding of the lake and land development. Restoration work at spawning beaches, since the population declined, has improved the extent of spawning habitat. Ensuring effective operation of the storage dam and fishway to ensure adult access is important. Freshwater factors are currently believed to have a limited to negligible impact on population survival, however, further research is warranted. Low smolt to adult survival in the ocean, due to natural and likely to a much lesser extent, fishing mortality, continues to be the major factor in preventing recovery (Withler et al. 2014).

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Appendix A –Tables and Figures

Table 1. Sakinaw sockeye adult counts. 1947-1994 counts are from BC-16 data. Insufficient data exists for 1995, 1997 and 1998. 1996 and 2002 counts used a fishway trap. 1999-2001 estimates are based on dive surveys at spawning beaches which are biased low compared to fishway counts due to in-lake mortality (estimated at up to 10% bias). 2003-2014 counts are from a digital video system set up in the fishway. "Estimate class" represents quality associated with the data collection: U = Unknown data collection; Type 1 data are a very good population estimate (nearly every fish counted through video tunnel); Type 2 data are still a very good population estimate (nearly every fish counted through video tunnel or fishway trap with perhaps a small portion of the population missed); Type 4 data are missing some days at the end of the migration when some fish may still be going through the fishway but are still a reasonable estimate of the population; Type 6 data are reliable for presence/absence only.

Year	Estimate Class	Clipped Jacks	Unclipped Jacks	Clipped Adults	Unclipped Adults	Total
1947	U	-	-	-	3500	3500
1948	U	-	-	-	4600	4600
1949	U	-	-	-	3931	3931
1950	U	-	-	-	2473	2473
1951	U	-	-	-	3450	3450
1952	U	-	-	-	6222	6222
1953	U	-	-	-	1131	1131
1954	U	-	-	-	4143	4143
1955	U	-	-	-	5079	5079
1956	U	-	-	-	2150	2150
1957	U	-	-	-	4300	4300
1958	U	-	-	-	4250	4250
1959	U	-	-	-	13000	13000
1960	U	-	-	-	4500	4500
1961	U	-	-	-	750	750
1962	U	-	-	-	3500	3500
1963	U	-	-	-	7500	7500
1964	U	-	-	-	3500	3500
1965	U	-	-	-	750	750
1966	U	-	-	-	3500	3500
1967	U	-	-	-	6000	6000
1968	U	-	-	-	14000	14000
1969	U	-	-	-	1200	1200
1970	U	-	-	-	5000	5000
1971	U	-	-	-	8000	8000
1972	U	-	-	-	4500	4500
1973	U	-	-	-	1500	1500
1974	U	-	-	-	6000	6000
1975	U	-	-	-	16000	16000
1976	U	-	-	-	6000	6000

Year	Estimate Class	Clipped Jacks	Unclipped Jacks	Clipped Adults	Unclipped Adults	Total
1977	U	-	-	-	1200	1200
1978	U	-	-	-	4000	4000
1979	U	-	-	-	11000	11000
1980	U	-	-	-	2800	2800
1981	U	-	-	-	3000	3000
1982	U	-	-	-	3400	3400
1983	U	-	-	-	1600	1600
1984	U	-	-	-	1115	1115
1985	U	-	-	-	2400	2400
1986	U	-	-	-	5400	5400
1987	U	-	-	-	4200	4200
1988	U	-	-	-	2500	2500
1989	U	-	-	-	1000	1000
1990	U	-	-	-	1200	1200
1991	U	-	-	-	500	5[illegible]
1992	U	-	-	-	1000	1000
1993	U	-	-	-	250	250
1994	U	-	-	-	250	250
1995	NI	-	-	-	-	-
1996	Type 4	-	-	-	222	222
1997	Type 6	-	-	-	Present, not counted	Present, not counted
1998	Type 6	-	-	-	Present, not counted	Present, not counted
1999	Type 4	-	-	-	14	14
2000	Type 4	-	-	-	112	112
2001	Type 4	-	-	-	87	87
2002	Type 2	-	-	-	78	78
2003	Type 1	-	-	-	3	3
2004	Type 1	-	-	0	99	99
2005	Type 1	-	-	7	21	28
2006	Type 1	-	-	0	1	1
2007	Type 1	-	-	0	0	0
2008	Type 1	-	-	0	0	0
2009	Type 1	-	-	1	0	1
2010	Type 2	-	-	28	1	29
2011	Type 1	-	-	555	0	555
2012	Type 2	-	-	0*	243*	243
2013	Type 1	-	29	0*	114*	143
2014	Type 1	10	2	0*	452*	464

* = Hatchery fish were not clipped BY 2008-2010.

Table 2. Sakinaw Sockeye adult length, collected from digital video system in the Sakinaw Lake fishway.

Length (cm)	Frequency		
	2004	2005	2013
26-30	0	1	0
31-35	0	1	2
36-40	0	6	10
41-45	1	0	11
46-50	14	3	9
51-55	48	11	6
56-60	32	15	15
61-65	3	3	17
66-70	0	4	22
71-75	0	0	3
76-80	0	0	3
81-85	0	0	1
n	98	44	99
Min	44	28	35
Mean	54.1	53.3	57.2
Max	63	69	84

Table 3. Sakinaw Sockeye average smolt fork length (in mm) 2014.

Smolt Year	Unclipped Sockeye		Clipped Sockeye	
	Age 1	Age 2	Age 1	Age 2
2003	120	128	118	151
2004	115	136	138	157
2005	-	-	-	-
2006	120	130	128	129
2007	139	-	151	-
2008	153	-	136	161
2009	145	-	141	-
2010	121*	152	-	155
2011	123	143*	-	-
2012	115**	121*	-	-
2013	111	146**	112	121
2014	117	134	116	131

* Unclipped hatchery release
** Mix of unclipped hatchery release and natural spawner progeny

Table 4. Sakinaw Sockeye smolt ages 2003-2014.

Smolt Year	Unclipped Sockeye			Clipped Sockeye		
	Age 1	Age 2	Total	Age 1	Age 2	Total
2003[a]	4194	140	4334	8080	0	8080
2004[a]	84	19	103	12	28	40
2005[b]	0	11	11	0	2	2
2006[a]	2891	35	2926	7207	1150	8357
2007[b]	272	0	272	3739	0	3739
2008[c]	182	0	182	11630	352	11982
2009[c]	222	0	222	62368	0	62368
2010[c]	63032	6506	69538	0	404	404
2011[c]	29783	3109	32892	0	0	0
2012[c]	161493	1384	162877	0	0	0
2013[c]	19759	8200	27960	214043	10532	224575
2014[c]	4168	266	4435	117994	3615	121610

a = stratify by length, b = no stratification, c = stratify by time

Table 5. Hatchery fry released, smolt counts and survival rates.

	Fry released			Smolt count			Survival %		
Brood year	Natural origin brood	Captive brood	Total	Clipped	Unclipped	Total	Hatchery fry to smolt	Marine (hatchery - clipped)	Marine (natural origin - unclipped)
1992	-	-	-	-	15880	15880	-	-	-
1993	-	-	-	-	2760	2760	-	-	-
1994	-	-	-	-	2500	2500	-	-	-
1995	-	-	-	-	5200	5200	-	-	-
1996	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-
2000	14981	0	14981	-	-	-	-	-	-
2001	31922	0	31922	8080	4334	12414	25.31%	0.087%	0.485%
2002	2784	0	2784	39	103	142	1.40%	0.000%	0.971%
2003	0	0	0	2	11	13	n/a	n/a	n/a
2004	25927	0	25927	8357	2926	11283	32.23%	0.000%	0.000%
2005	7588	87877	95465	3739	272	4011	3.92%	0.027%	0.000%
2006	0	84626	84626	11982	182	12164	14.16%	0.234%	0.549%
2007	0	420781	420781	62370	222	62592	14.88%	0.890%	n/a
2008	0	726376	726376	404	69538	69942	9.63%	0.347%	n/a
2009	0	329360	329360	0	32892	32892	9.99%	0.347%	n/a
2010	5110	1368712	1373822	0	162877	162877	11.86%	0.278%	n/a
2011	0	963328	963328	224575	27960	252535	23.31%	-	-
2012	0	856205	856205	121468	4435	125902	14.19%	-	-
2013	0	320416	320416	-	-	-	-	-	-

Table 6. Fishway counts as fish enter the lake and dive counts. Dive counts are not reliable estimates of number of fish in the lake or associated in-lake mortality given the difficulty in finding the fish in a large lake and number of days between dives.

Year	Fishway Count	Dive Count Total
1999	No count	0
2000	No count	20
2001	60	29
2002	78	43
2003	3	No dives
2004	99	91
2005	24	22
2006	1	No dives
2007	0	No dives
2008	0	No dives
2009	1	0
2010	29	24
2011	554	465
2012	244	219
2013	143	135
2014	464	286

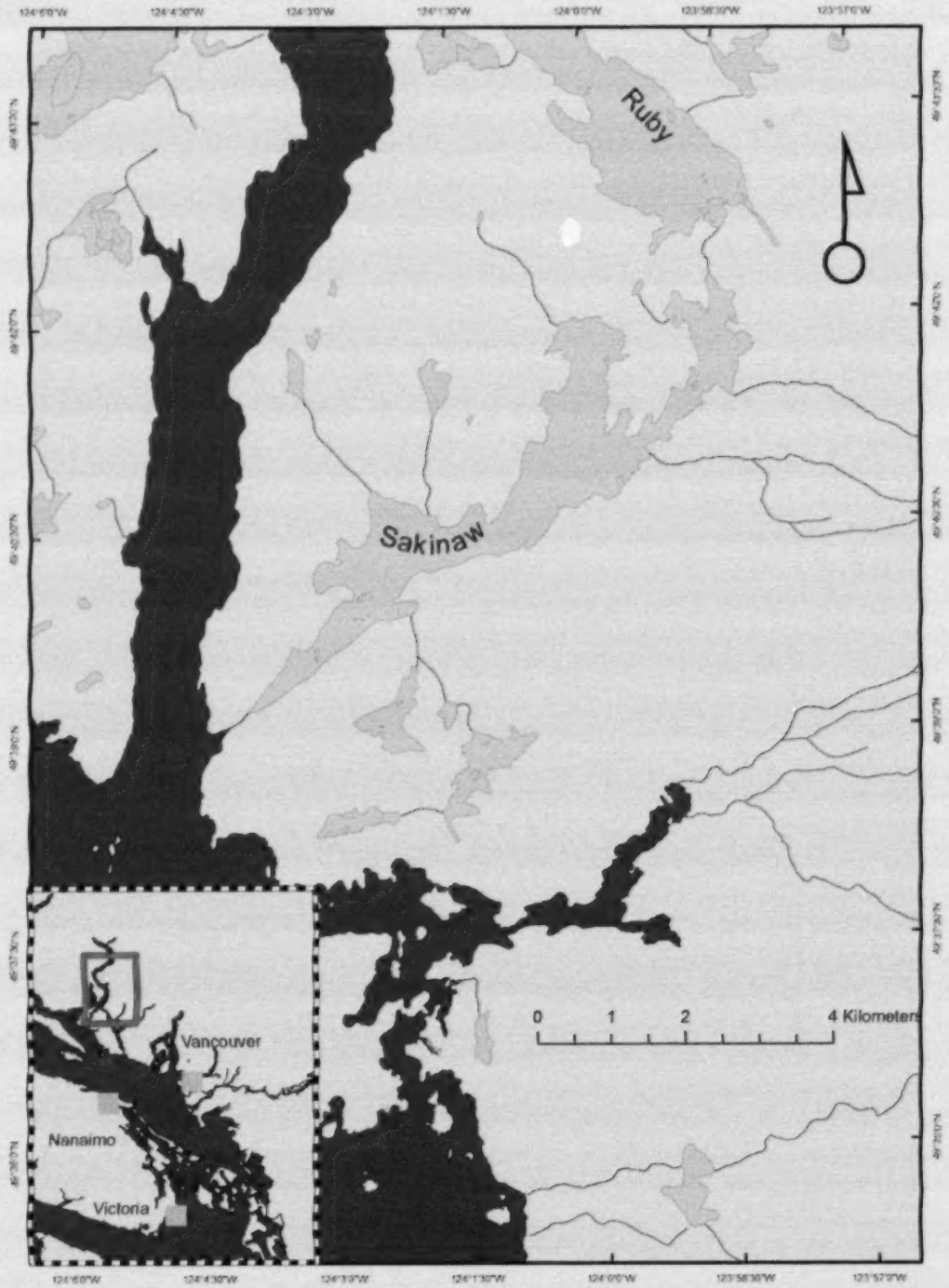

Figure 1 Sakinaw Lake (light blue) located on the Sechelt Peninsula, BC coast. Strait of Georgia is to the west (dark blue).

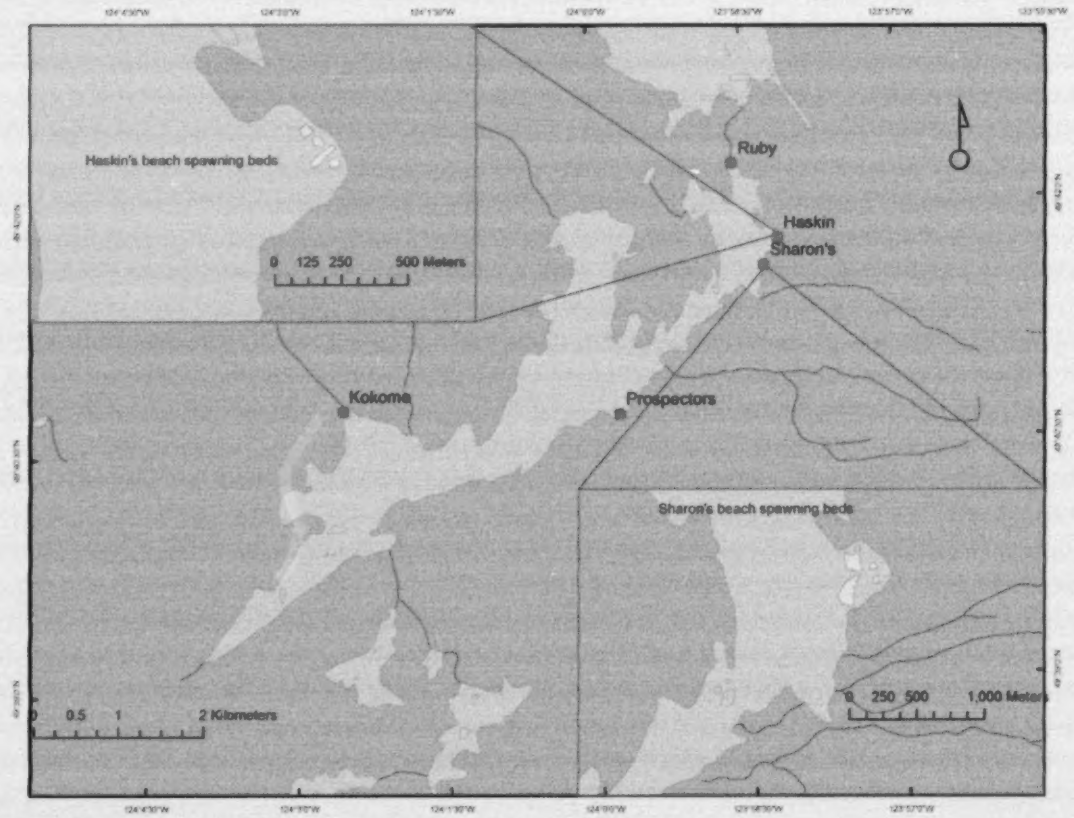

Figure 2. Sakinaw Lake spawning beaches. Spawning is currently known to occur at Sharon's, Haskin's and occasionally at Ruby beach. Green polygons represent spawning beds.

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